Engine and Vehicle Integration Activity Session

U.S. Department of Energy Natural Gas Vehicle Technology Forum Technical Committee Meeting January 28, 2003

Session Agenda

1:15-1:35	**Overview and NGNGV Update**	
1:35- 3:00	**Presentations and Panel Discussion on HD Engine Technology**	
	• SING, DI/PING –vs- Diesel	Patric Ouellette, CWI
	• Port Injection/PING	Kevin Walkowicz, NREL
	• SI/Stoich	Alex Lawson, TeleFlex GFI
	• Other Emerging Technologies	Kevin Walkowicz, NREL
3:00 - 3:10	**Break**	
3:10 – 3:40	**Aftertreatment for Natural Gas**	
	•Joe Kubsh, MECA	
3:40 – 4:10	**Presentation on Challenges and Opportunites in LDV's**	
	•Ford Motor Company	Rich Williams
4:10 – 4:40	**Discussion / Q&A**	

HVERG Vehicle Summary

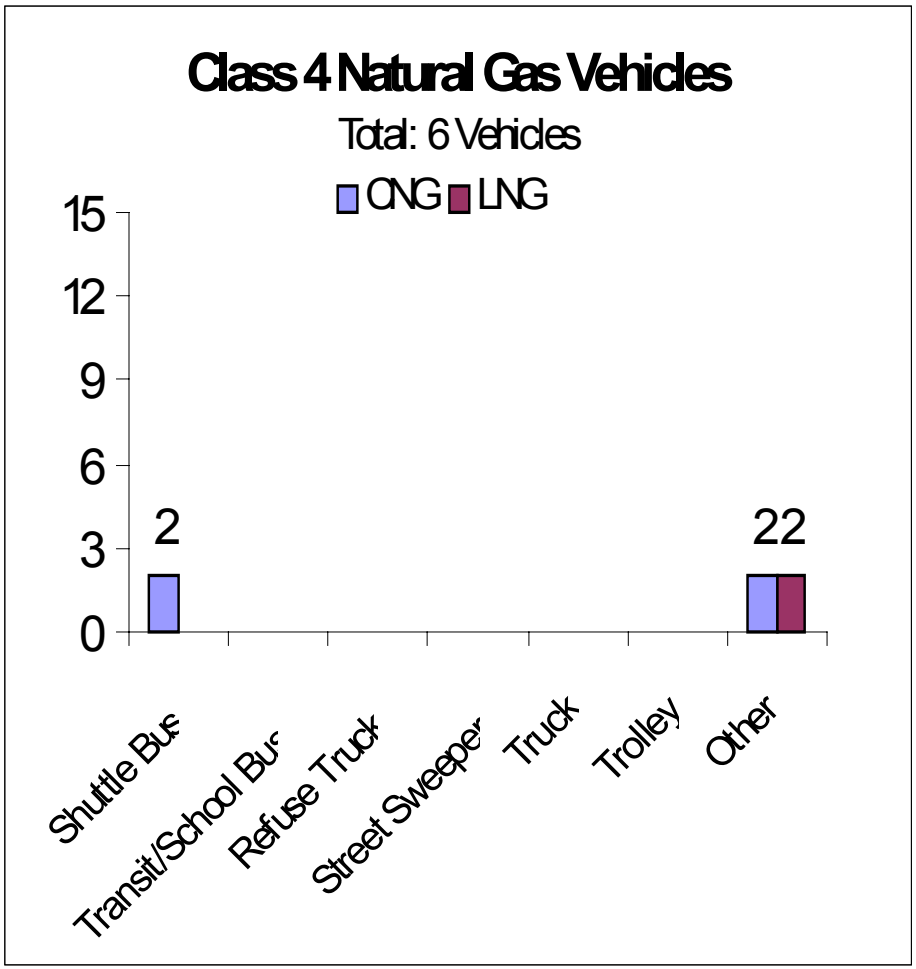
NGV Technology Forum

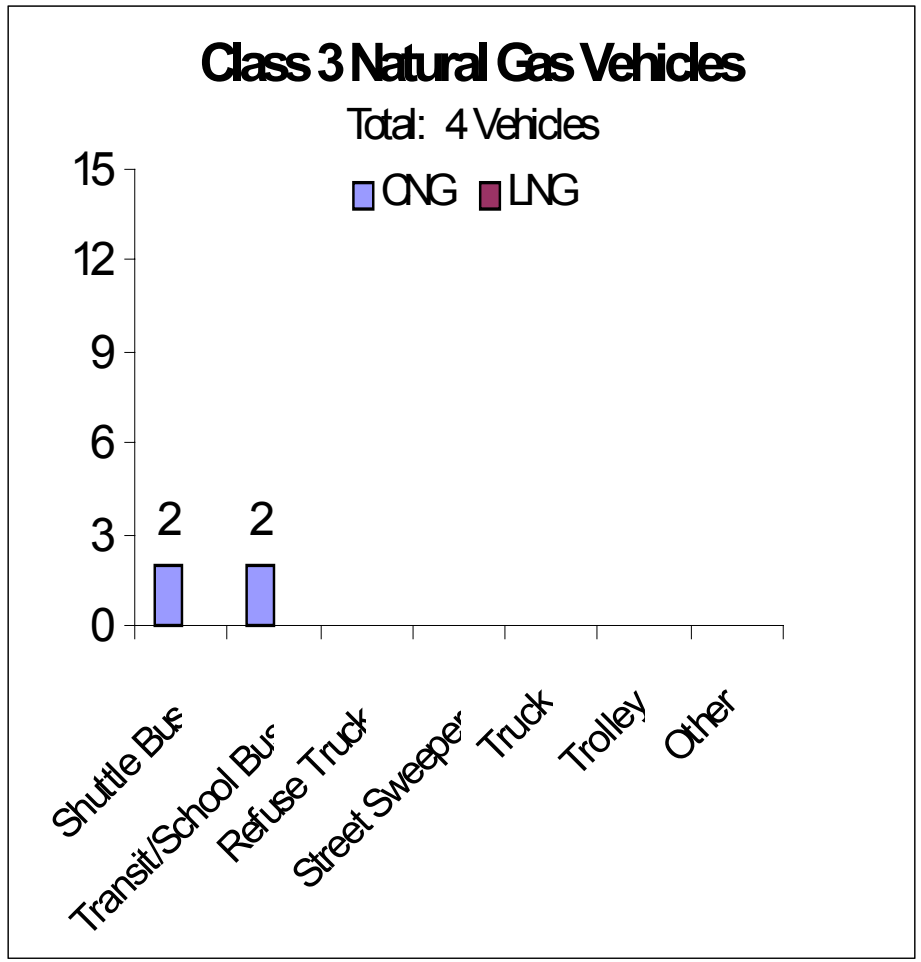
HDV Natural Gas Vehicle Suppliers	Models Available
Blue Bird Corp	4
Champion Bus, Inc.	6
Chance Coach, Inc.	2
Crane Carrier Co.	5
El Dorado National	5
Elgin Sweeper Co.	3
Equipement Labrie	2
Ford Motor Co.	1
Freightliner Custom Chassis	2
Freightliner Trucks	2
Kalmar Industries Corp.	2
Mack Trucks, Inc.	4
Motor Coach Industries	1
Neoplan USA Corp.	6
New Flyer of America	4
North American Bus Industries	4
Nova Bus Inc.	2
Omnitrans	2
Orion Bus Industries	1
Peterbilt	12
Spartan Motors Chassis	4
Supreme/Specialty	1
Thomas Built Busses	1
Tymco	1
Volvo Trucks North America	2

Total = 79

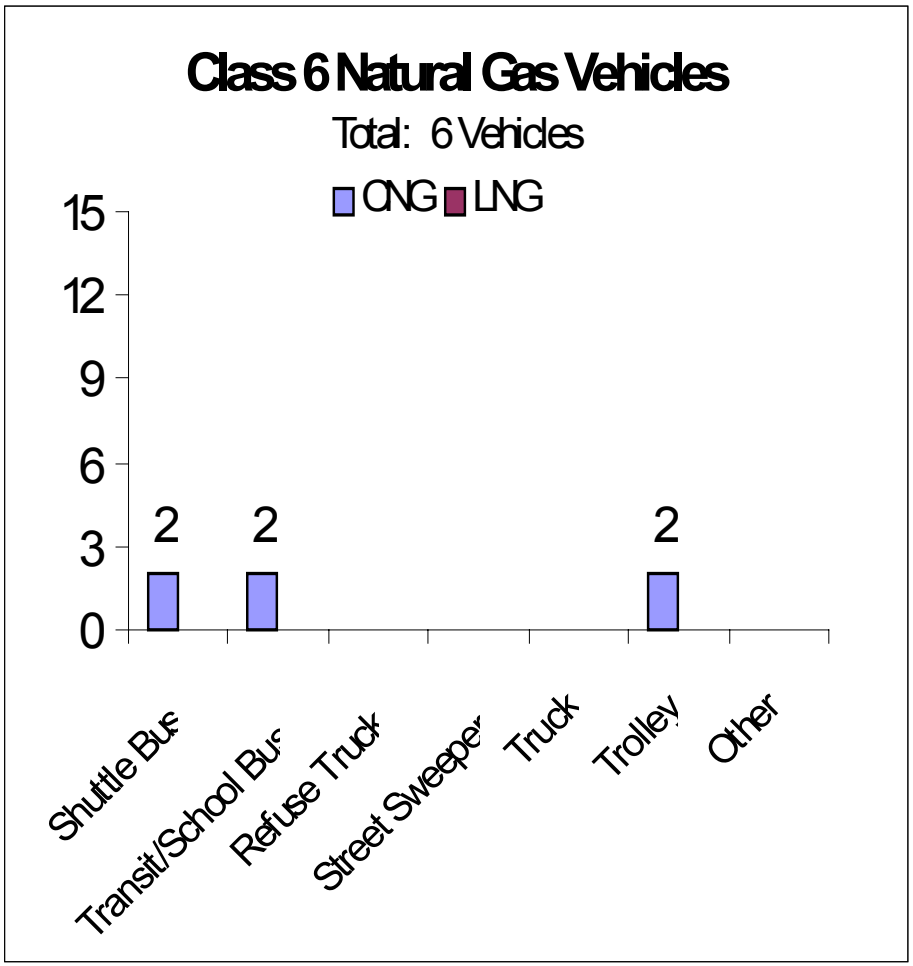
HVERG Vehicle Summary

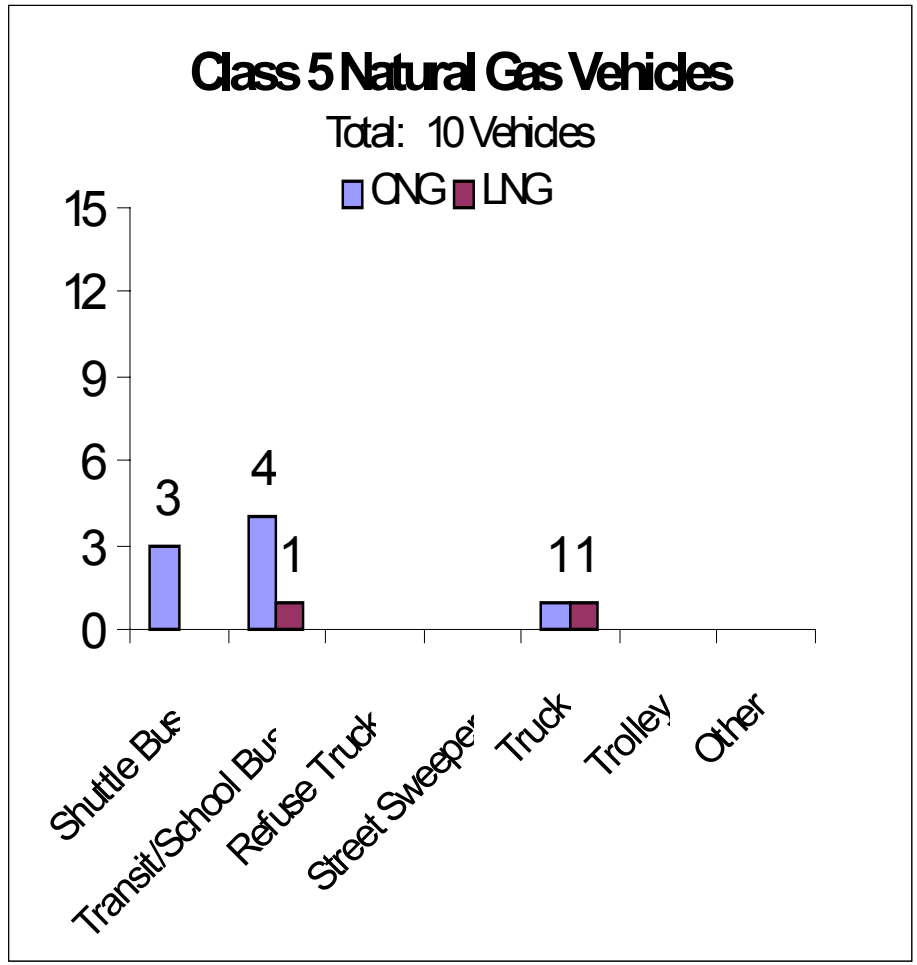
NGV Technology Forum



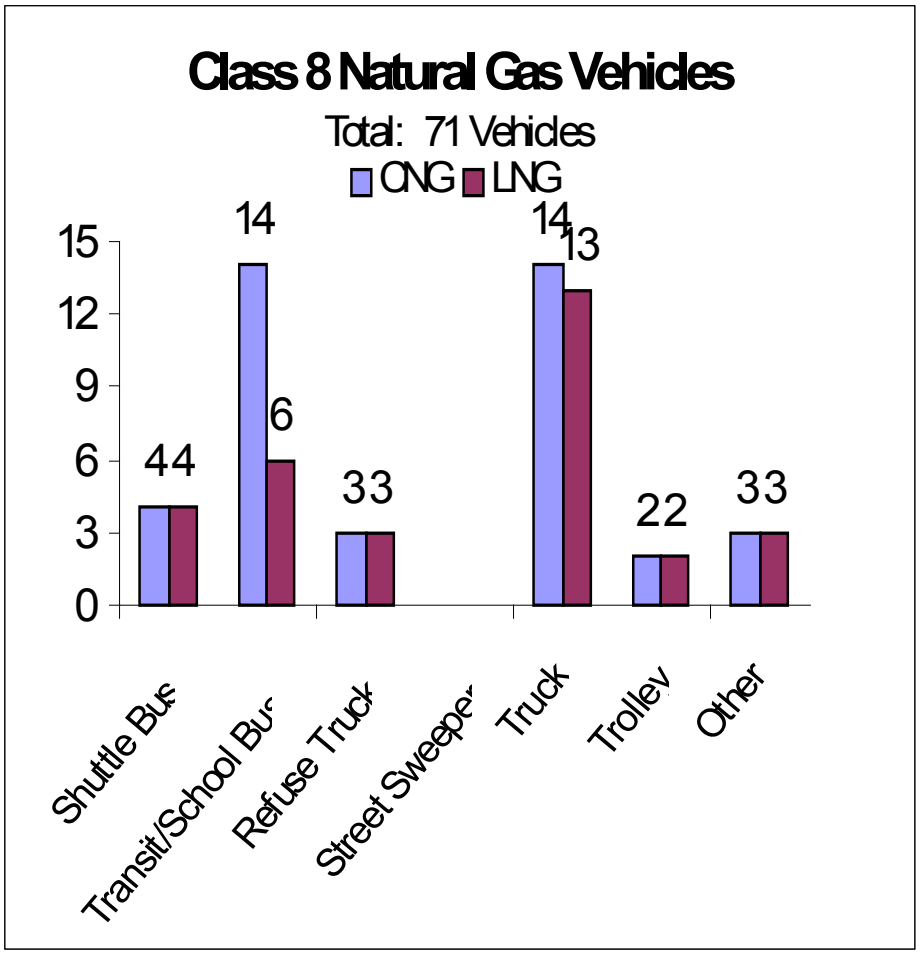


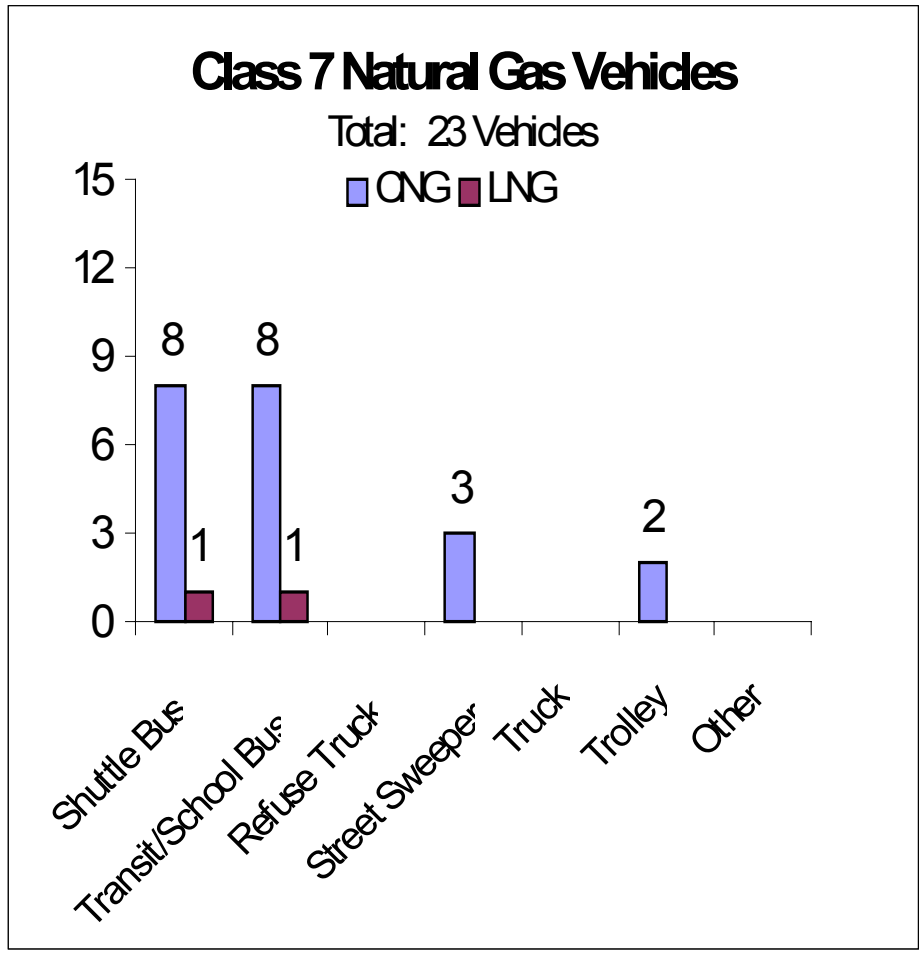
HVERG Vehicle Summary



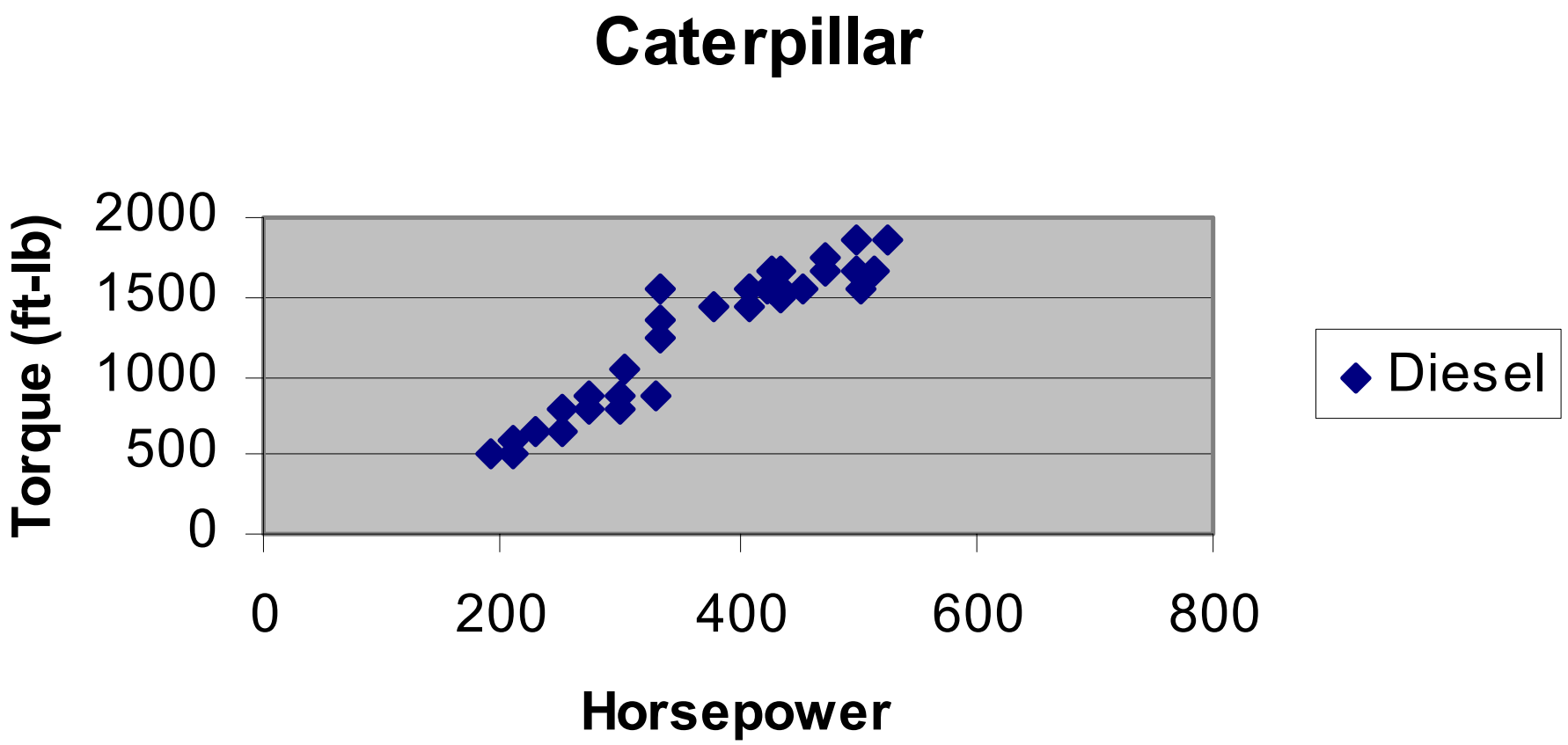


HVERG Vehicle Summary





HD Engine Availability Examples



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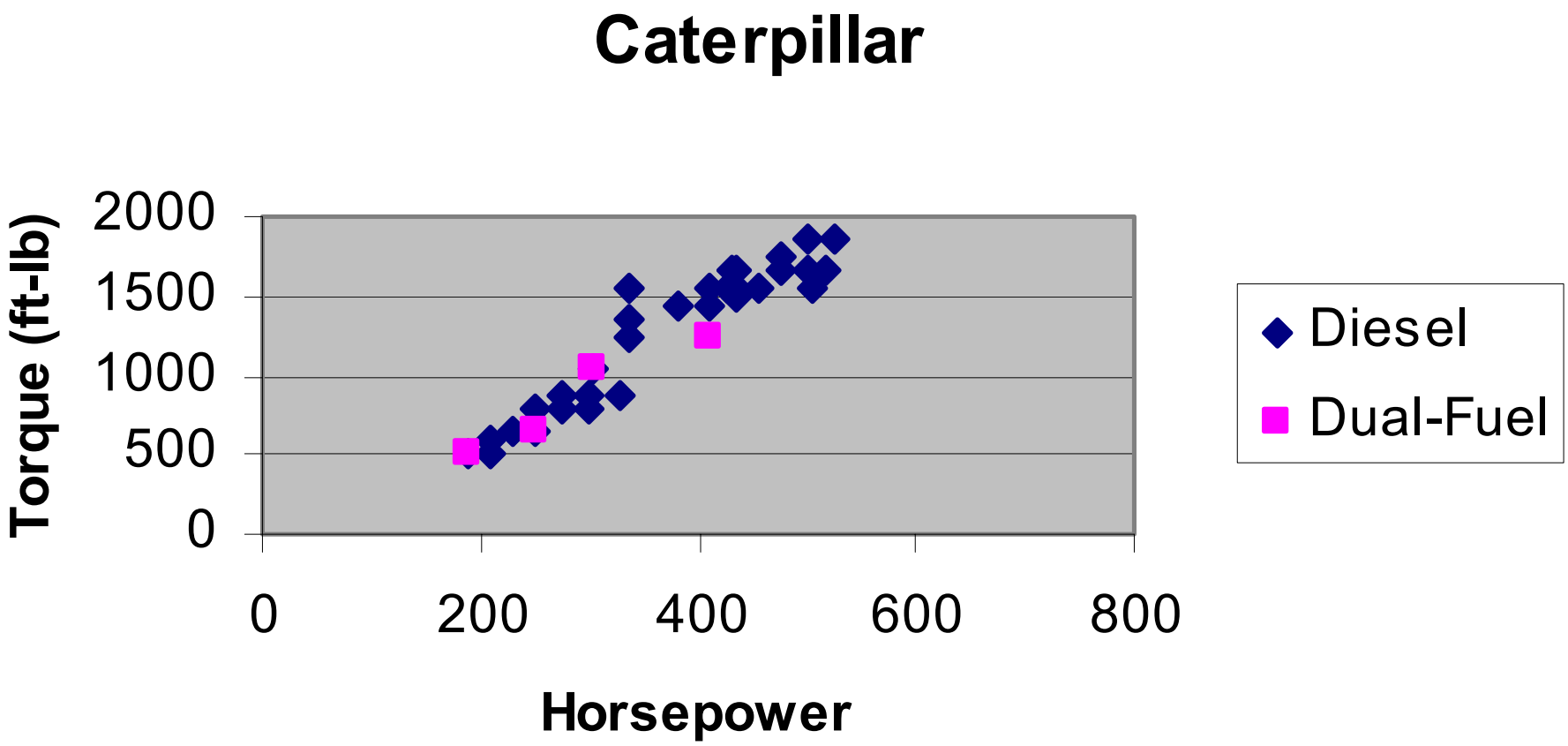

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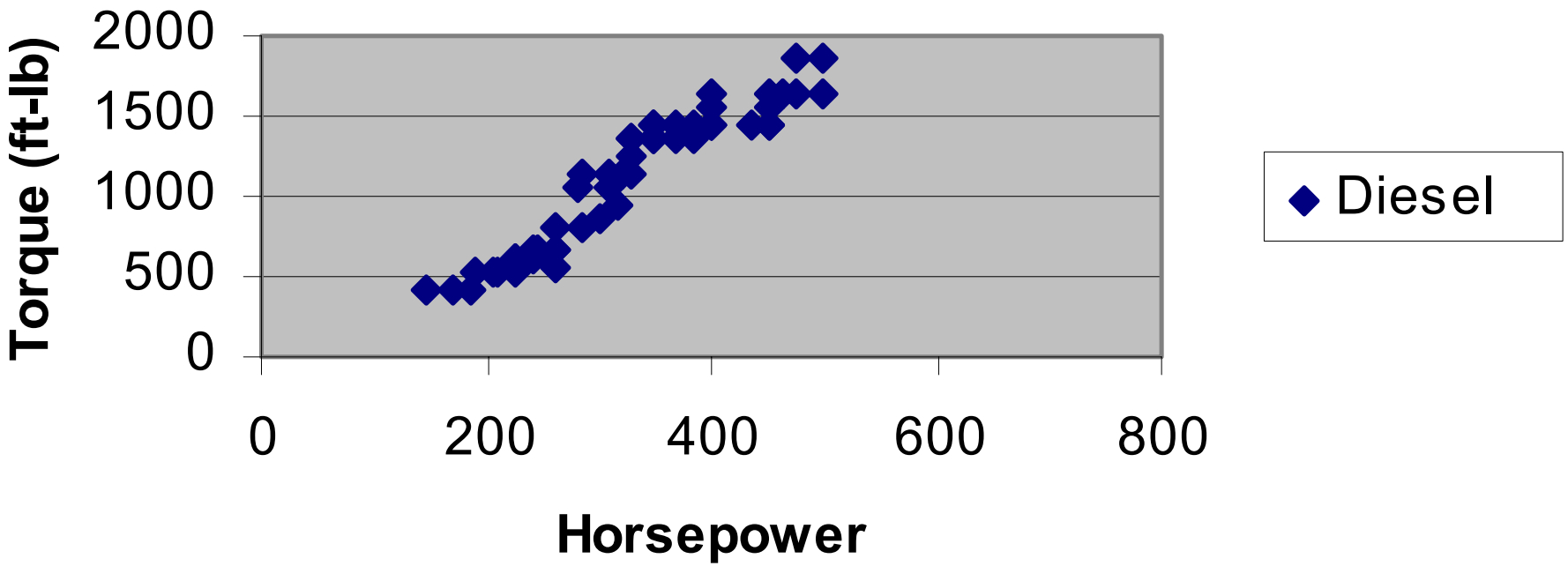

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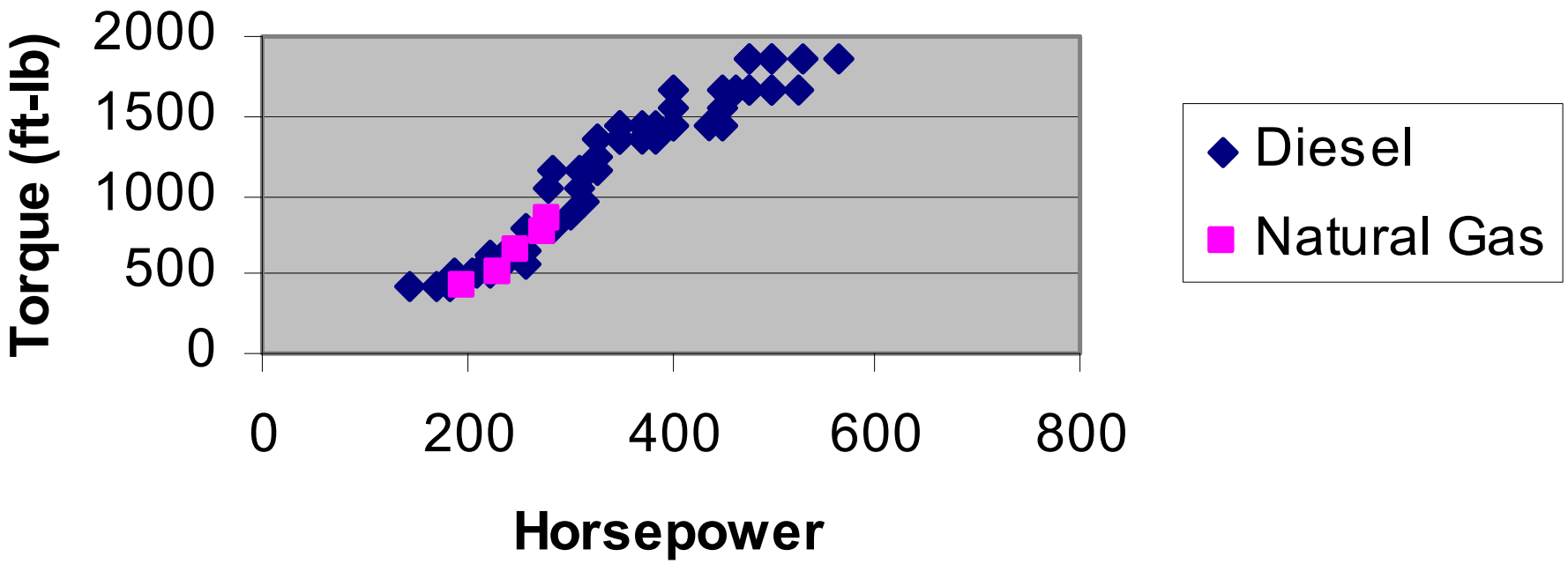

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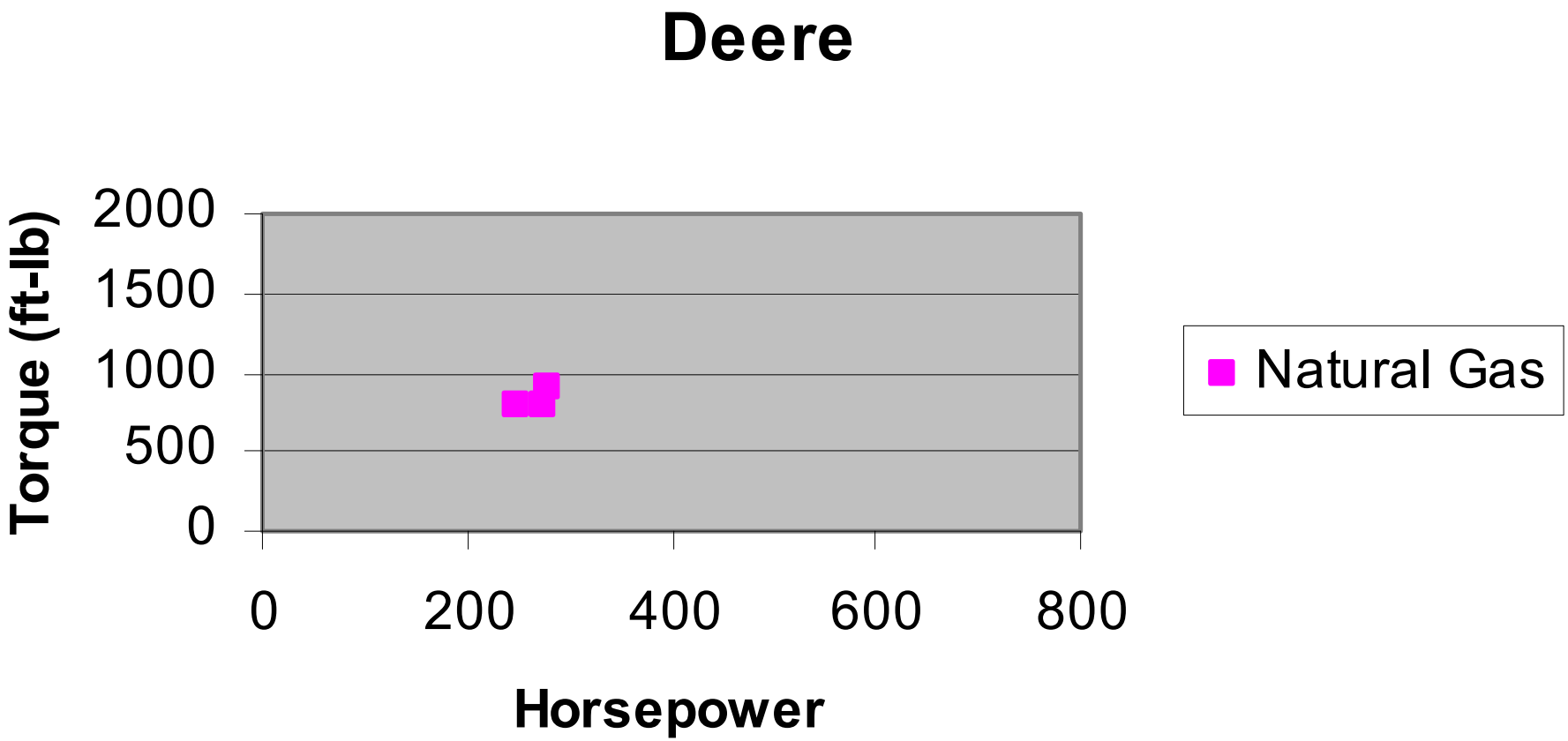

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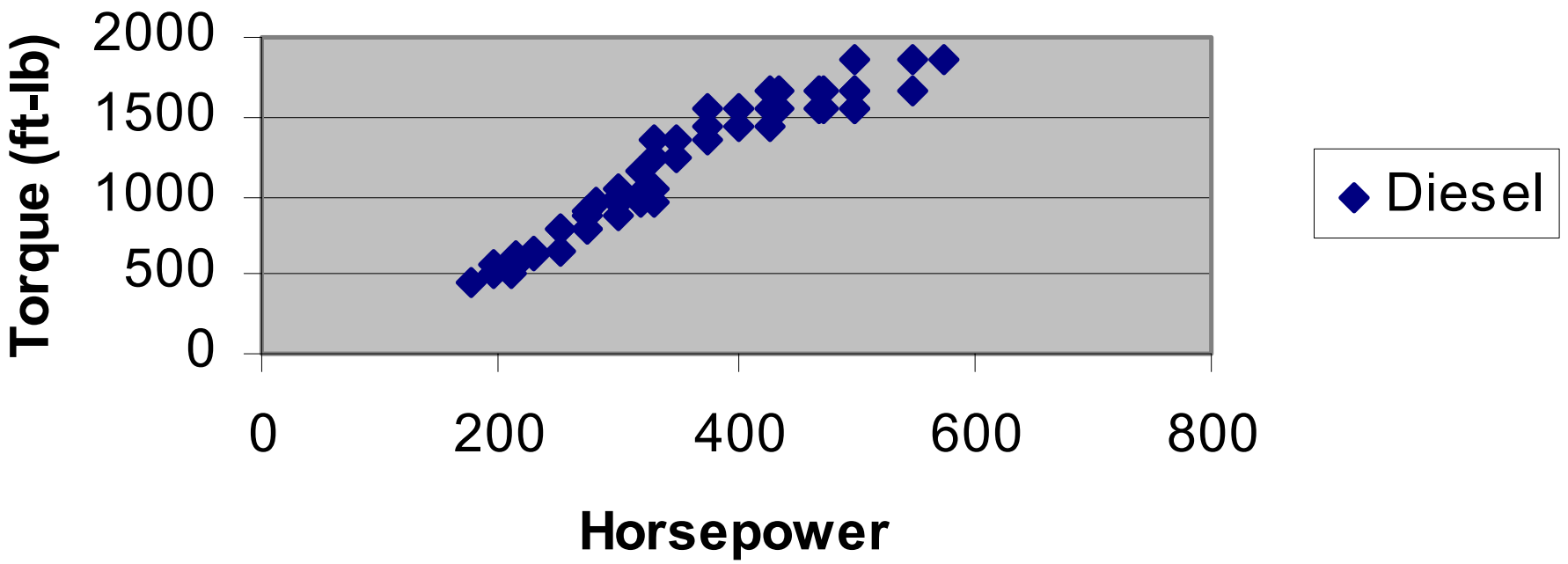

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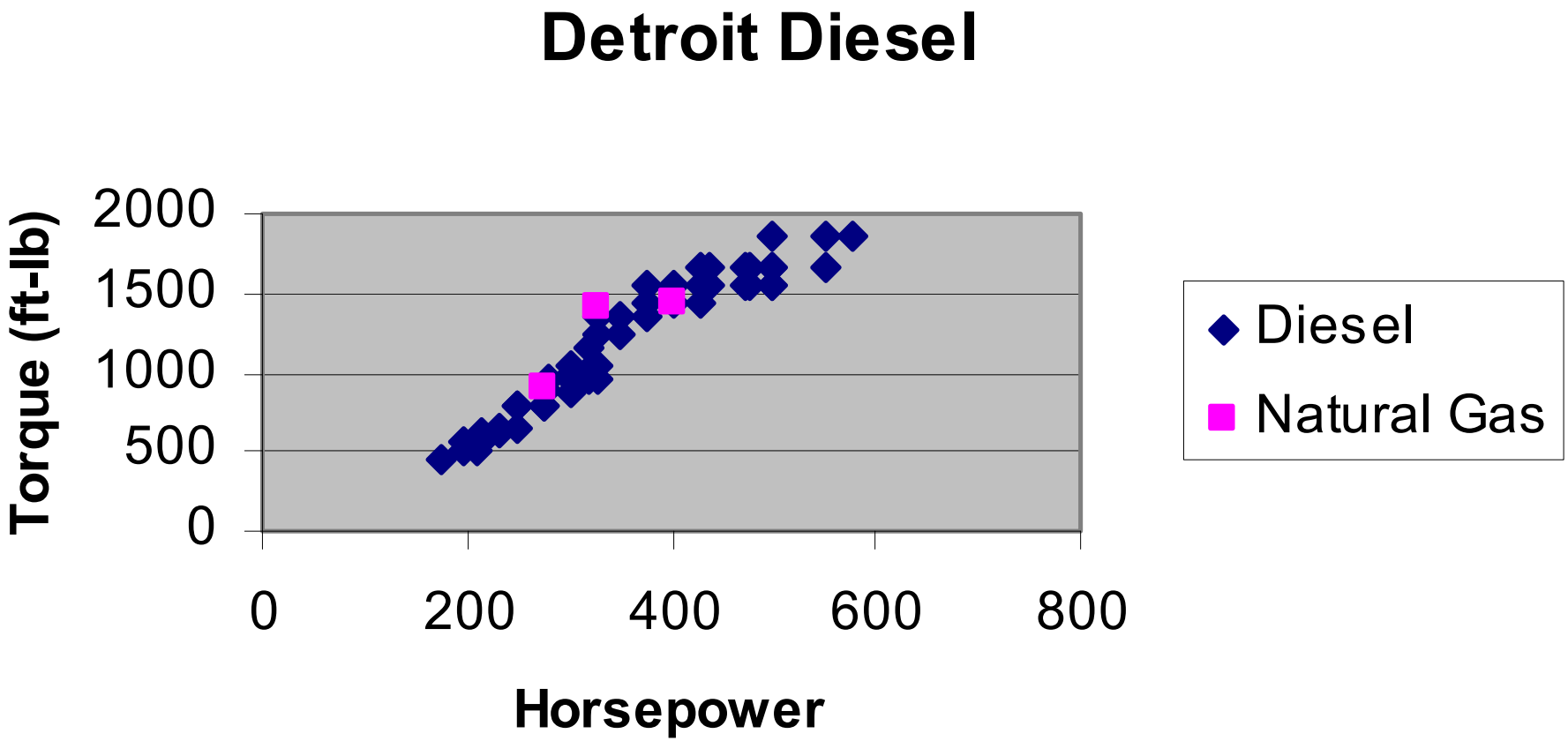

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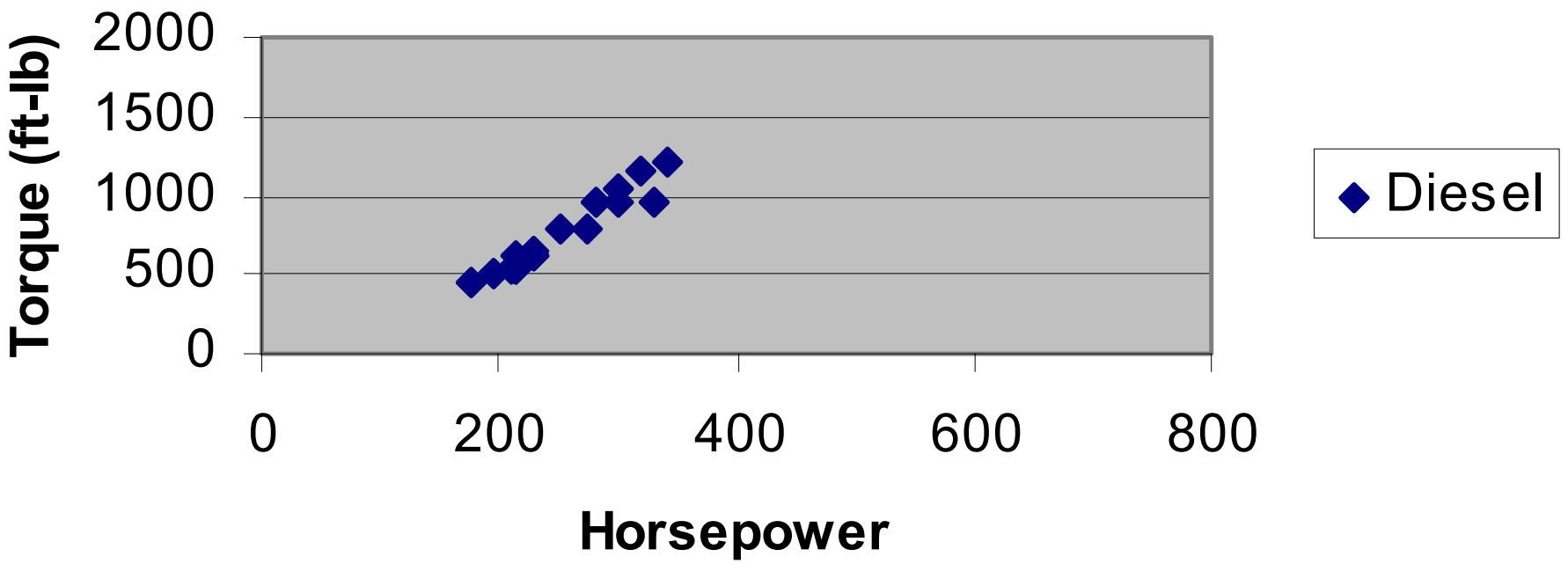

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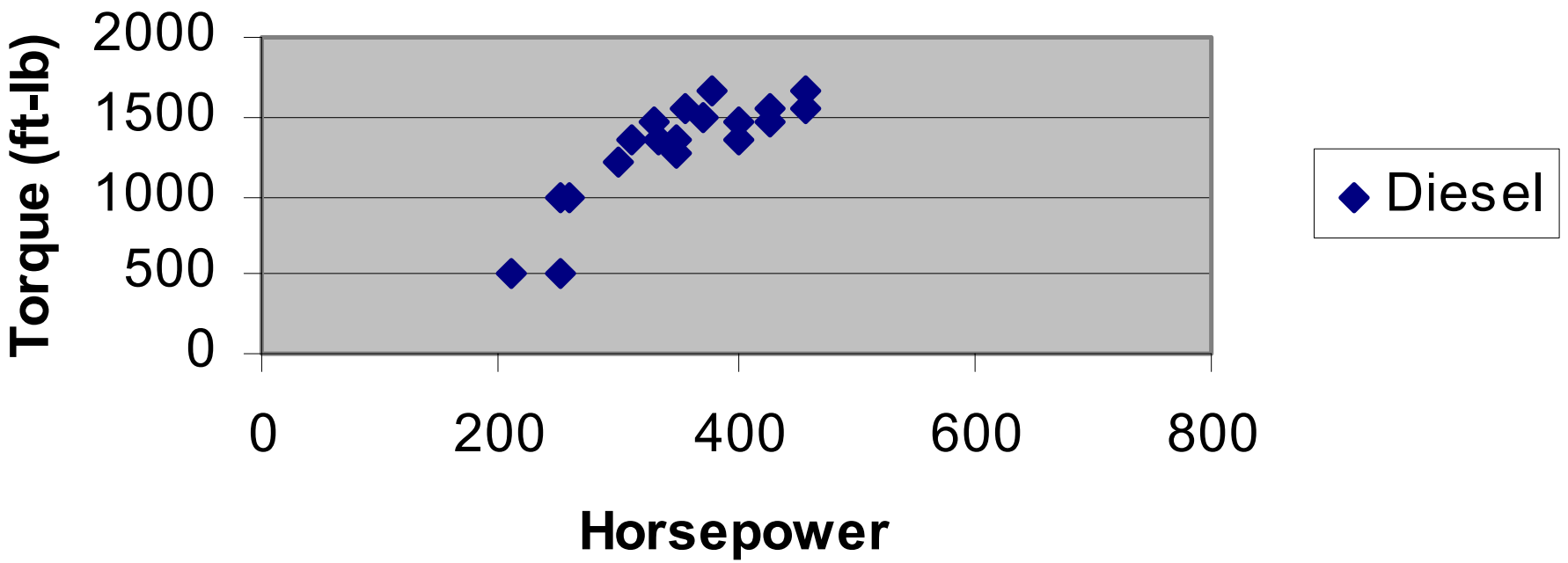

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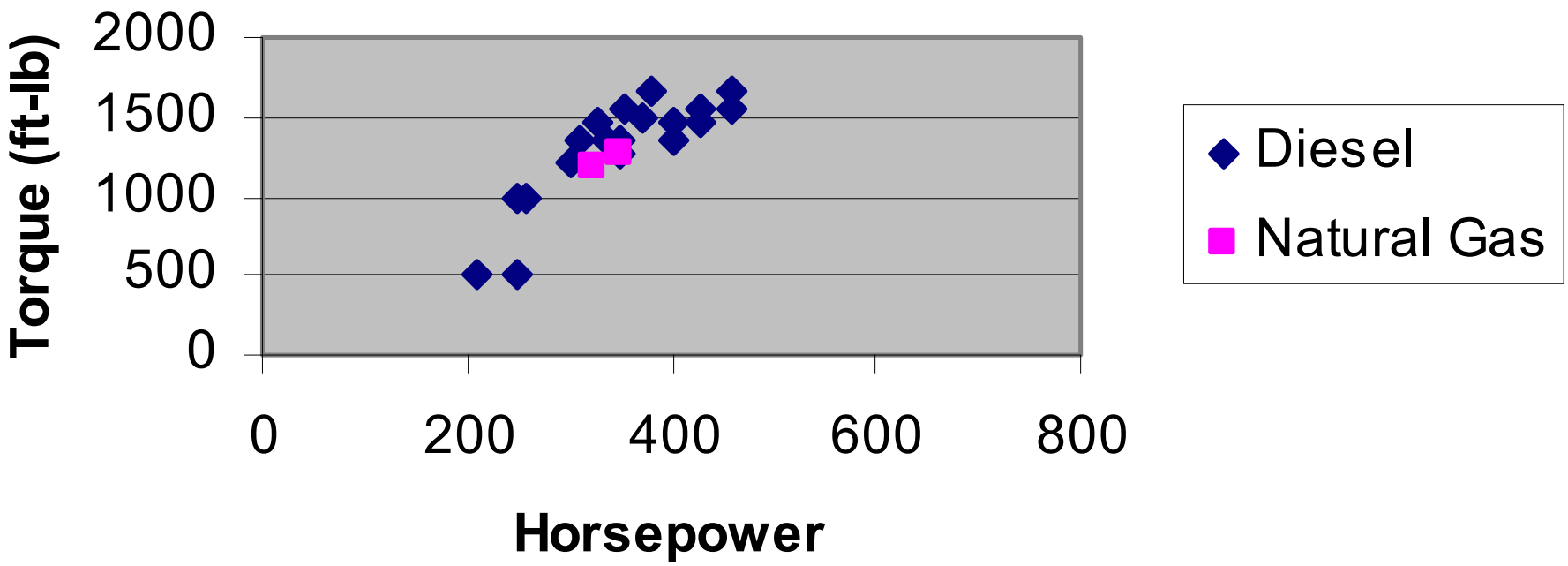
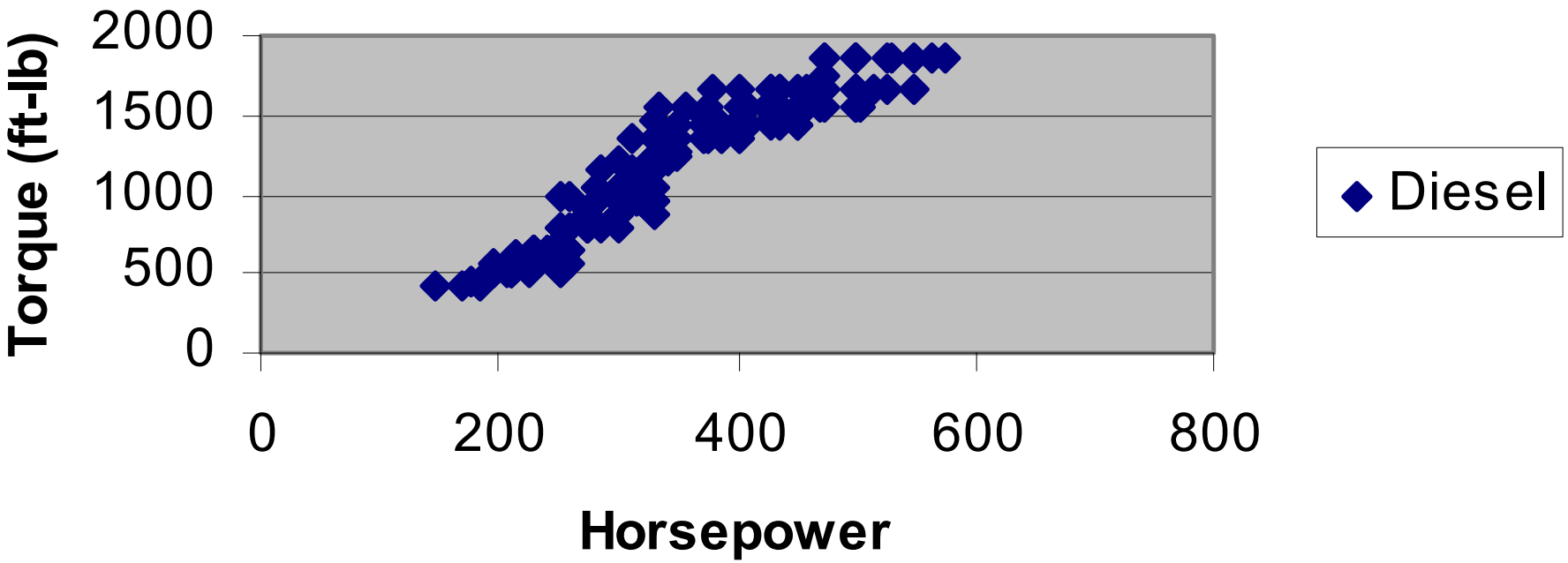


HD Engine Availability Examples

MD and HD Automotive Engines



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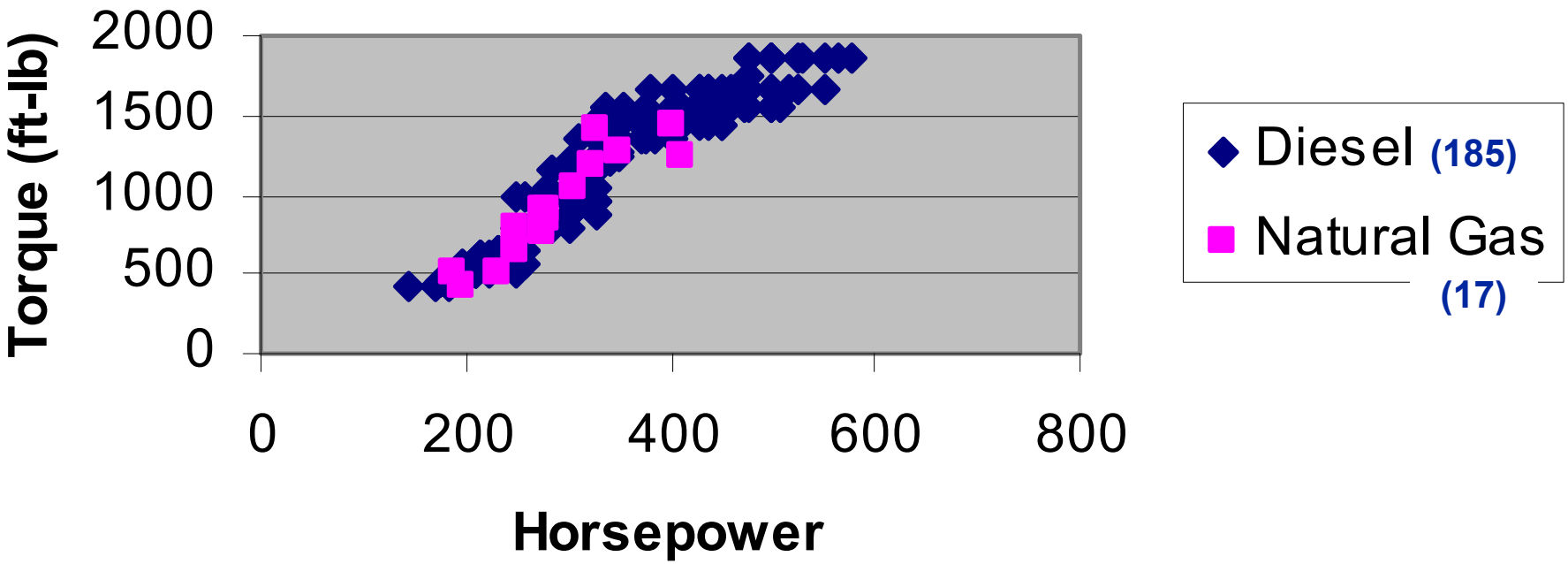
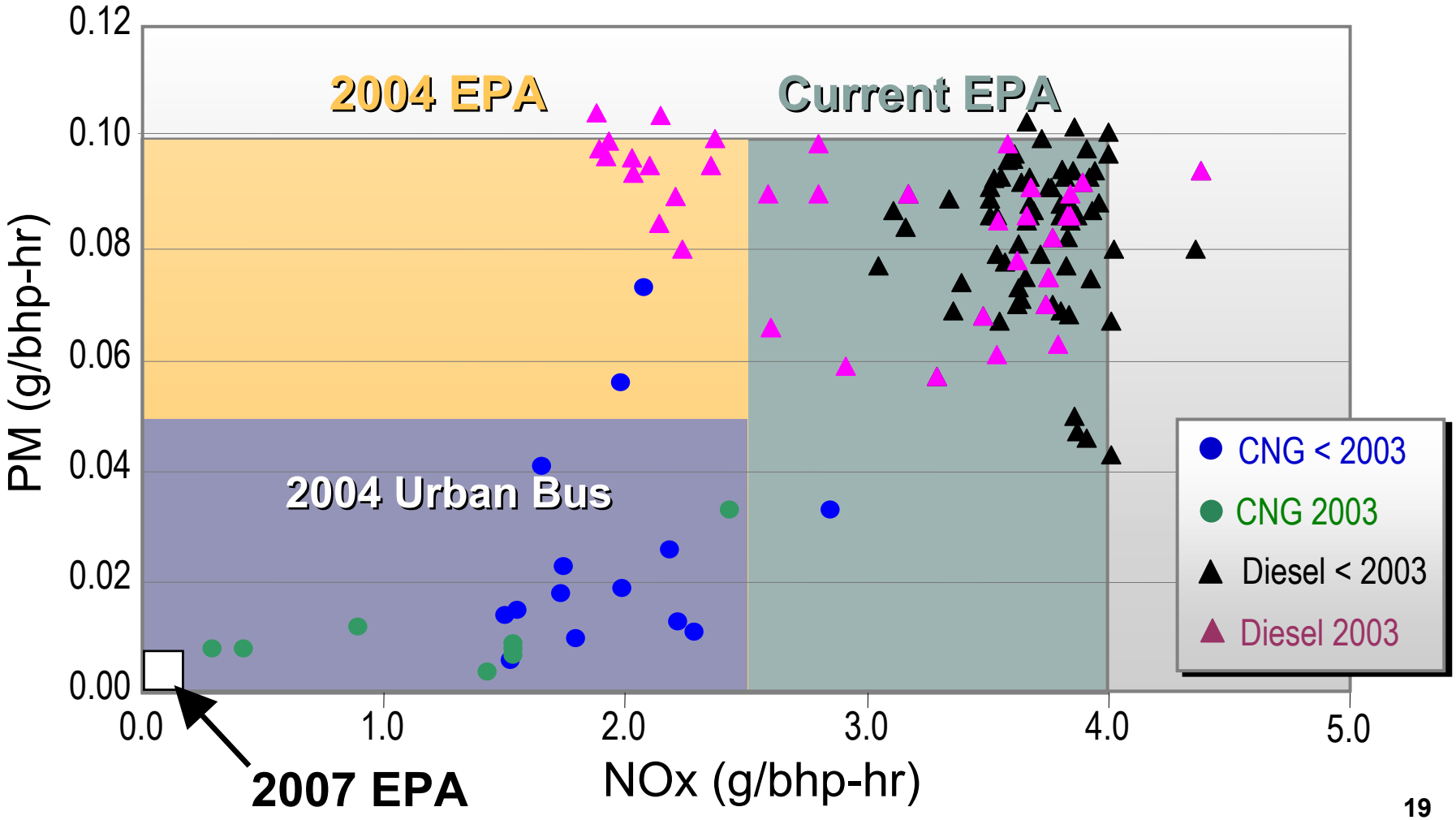
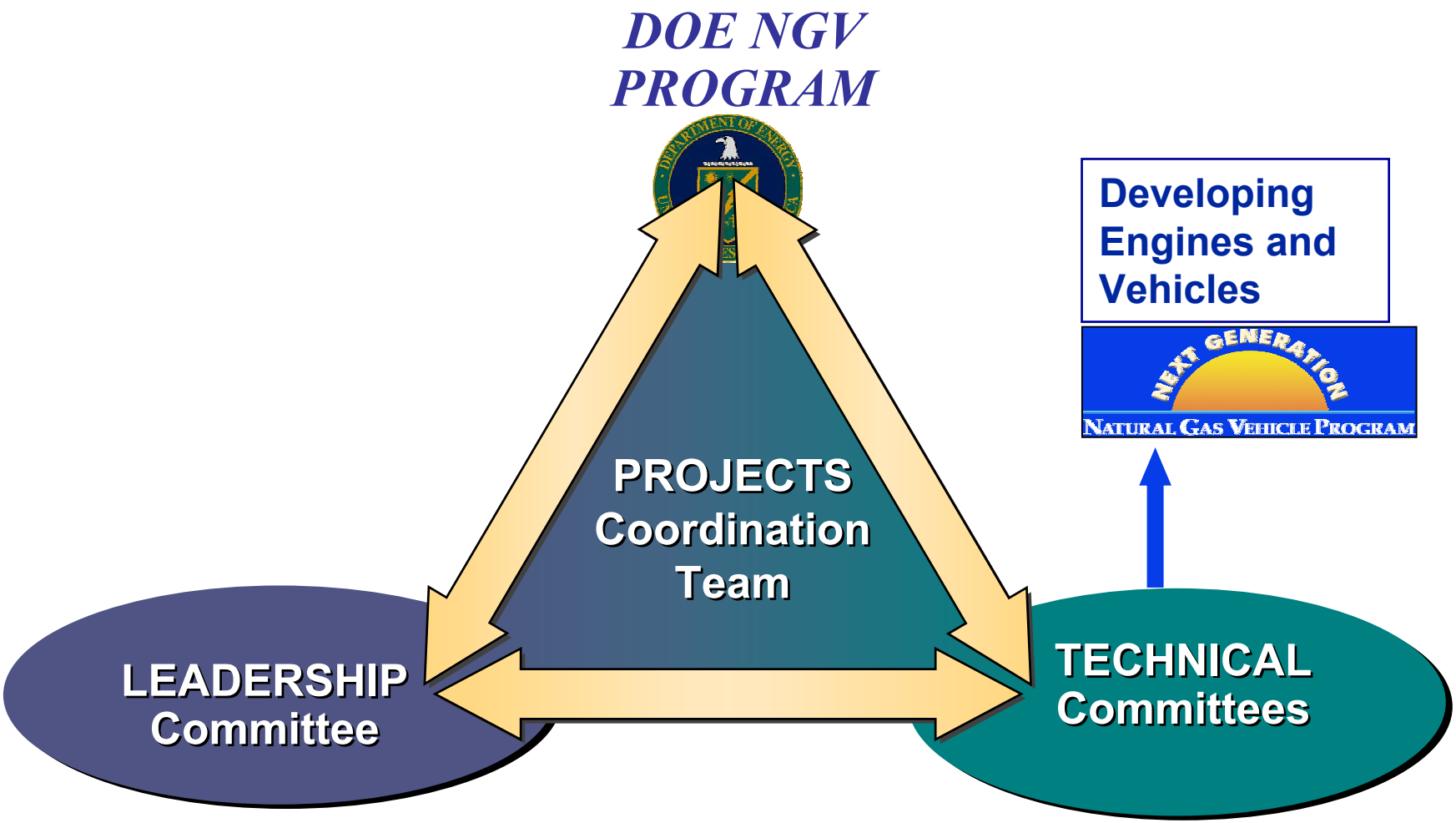


Emissions and DOE Engine Programs

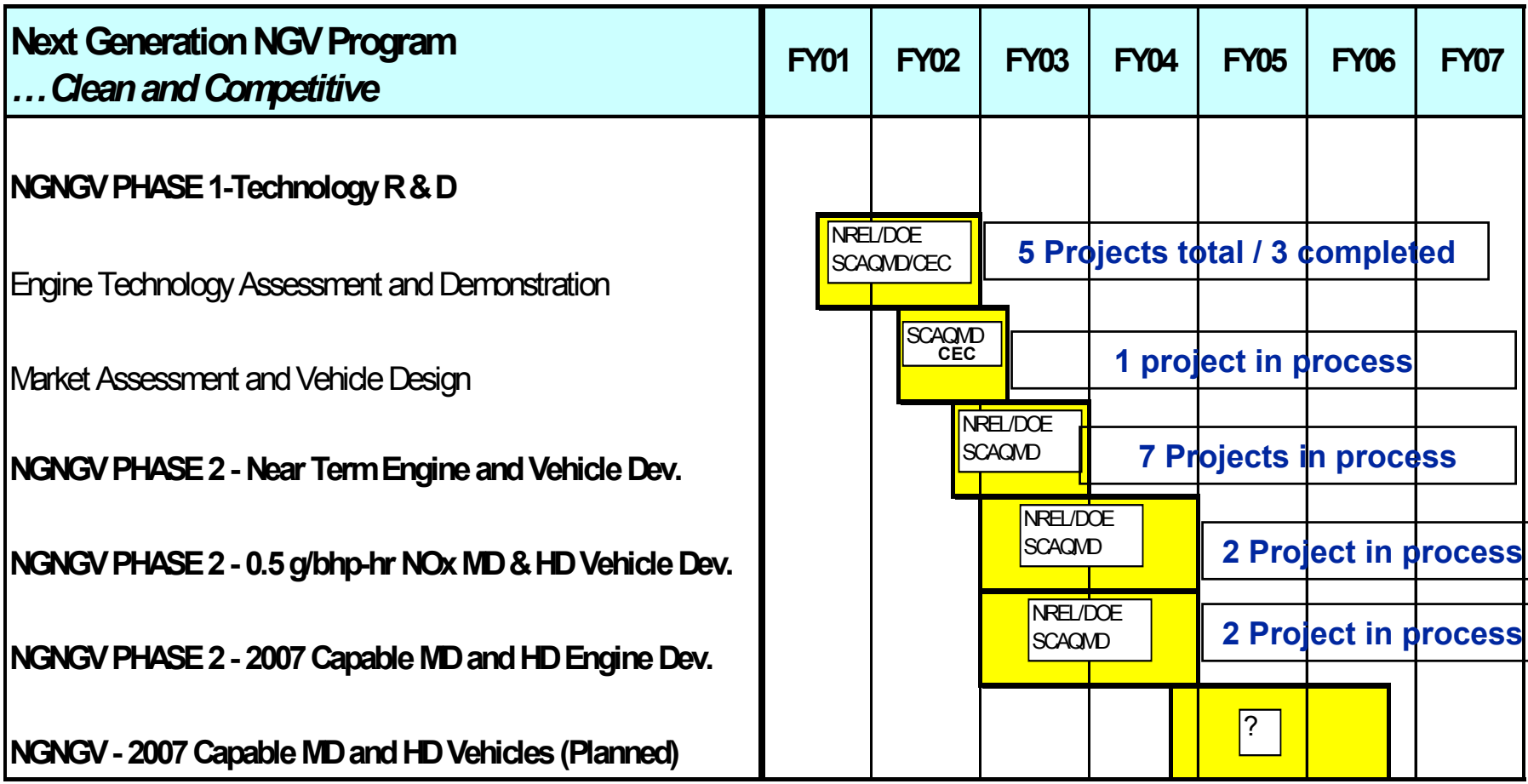


NGNGV Update



Status Report on NGNGV Projects funded by DOE, SCAQMD and CEC

NGNGV Update: Summary of Projects



Status Report on NGNGV Projects funded by DOE, SCAQMD and CEC

- **NGNGV Update: Phase I: Technology R&D**
  - **Task A: Engine Technology Assessment and Demonstration**
    - » 5 Projects:
      - **TeleFlex GFI:** demonstration of a 6.0L GM engine with a three-way catalyst to achieve well below 0.2 g NOx (2 Projects)
      - **CWI:** demonstration of the 5.9+ engine with a lean NOx adsorber to achieve 0.5 g NOx
      - **TIAX:** demonstration of a catalyzed glow plug in a lean burn diesel engine to achieve 0.5 g NOx and improved engine durability
      - **Clean Air Partners:** demonstration of Caterpillar C12 engine with both active and passive catalysts to achieve 0.2 g NOx
  - **Task B: Market Assessment and Vehicle Design**
    - » 1 Project:
      - **PACCAR/Cummins Westport**: Market assessment and vehicle integration strategy to determine best overall market strategy for both 0.5 and 0.2 g NOx vehicles

Status Report on NGNGV Projects funded by DOE, SCAQMD and CEC

NGNGV Update: Platform Development – 4 projects

- **Using "off the shelf", commercial natural gas engines (Deere 8.1L)**
  - » New Flyer transit bus (280hp)
  - » Autocar/Volvo Expeditor front loader refuse truck (280hp)
  - » Freightliner FL70 utility truck (250hp)
  - » Freightliner FL70 delivery truck (250hp)
- **Vehicles should be ready for service by Fall 2003**

Status Report on NGNGV Projects funded by DOE, SCAQMD and CEC

NGNGV Update - Near Term Natural Gas Engine Development (1.5-1.8 g NOx+NMHC) – 3 Projects

- Currently in contract negotiations with:
  - **Detroit Diesel Corporation:** Developing 6.9 L, 275 hp/ 730 lb-ft (M906 6 cyl.), integrate into school bus to fully develop, certification target of 1.5 NOx + NMHC, 0.03 PM
  - **Cummins Westport Inc.:** Developing 8.9 L (ISL), 320 hp, 950 lb-ft, integrating into refuse hauler to fully develop, certification target of 1.8 g NOx + NMHC, 0.05 PM
  - **NGV EcoTrans/Deere:** Developing 8.1 L, 250 hp, 800 lb-ft, integrate into pick up and delivery vehicle to fully develop, certification target of 1.8 g NOx + NMHC (co-funded by SCAQMD and NREL)

- Engines will be developed by engine OEMs then field tested in a vehicle application to demonstrate commercial readiness and in-use performance
- Engines should be ready for sale by late Fall 2003

Status Report on NGNGV Projects funded by DOE, SCAQMD and CEC

NGNGV Update: Phase 2 : Engine and Vehicle Development (4 Projects)

- Currently in contract negotiations with:
  - **Medium Duty Vehicle: Gas Technology Institute / OEM / ARBOC:** Dedicated V-10 CNG with a three way catalyst powering a low floored bus chassis. 2 year project: develop engine, integrate into vehicle, demo in fleet.
  - **Heavy Duty Vehicle: Mack:** Dedicated LNG (E7G, 325 hp, 1250 lb-ft) with a three way catalyst, variable geometry turbo, and EGR powering a refuse hauler and being demonstrated and tested by Waste Management. Possible coordination with landfill gas development effort.
  - **Medium-duty Engine: Cummins Inc.:** Develop next generation of combustion recipes including A/F ratio control, turbomachinery (that could include VG turbo) and aftertreatment systems. Targeted 2006 implementation.
  - **Heavy-duty Engine: Mack:** Project to utilize advanced, air/fuel handling mechanisms with EGR to maintain lean burn efficiency and utilize three way catalyst. 2 year project, engines targeted for 2005.

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Emerging Technology:
Hot Surface Ignition of Directly Injected Natural Gas

Benefits:

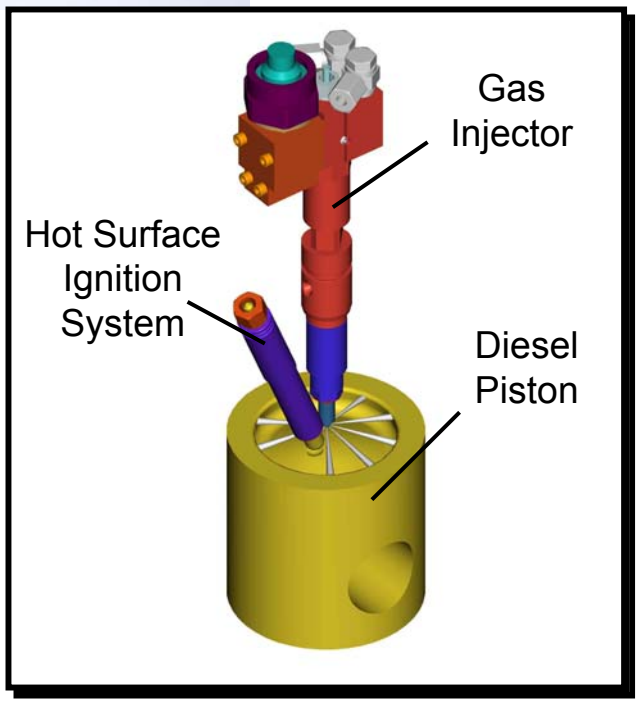
- Diesel engine based
- High thermal efficiency
- High torque
- Low particulates/smoke
- Low CO2 emissions

Challenges:

- Control and protection of glow plug for durability
- Control of combustion and THC at light load

Directly-Actuated Injector

Using dedicated high-pressure, common-rail, natural gas injectors



Slide courtesy of Westport Innovations

Emerging Technology: Micro Pilot® Ignition

- MicroPilot® natural gas engine combines the advantage of low NOx emissions of a spark-ignited, lean-burn natural engine, with the high efficiency and power density of a diesel engine
- MicroPilot® engine is a dedicated natural gas engine with a MicroPilot® diesel injector used for ignition rather than a spark plug (around 1% diesel, 99% natural gas)
- Retaining the time-proven direct diesel injection technology as the ignition source changes how the engine burns fuel, from a typical spark-ignition process to compression-ignition
  - Provides reliable and much higher energy, power and ignition intensity and evenly distributed ignition sources over the space of combustion chamber, as compared to a single ignition source from spark plug)
  - The high burn rate for pilot fuel droplets provides a higher burn rate for the 99% homogenous gas and air charge as compared to spark gas
- It is the increased ignition intensity that permits extension of lean combustion limit, accompanying drop in peak temperature (lower NOx emissions)
- Lube oil could potentially be used as pilot fuel replacing diesel, eliminating oil change/disposal, and diesel fuel tank
- Clean Air Partners has demonstrated the MicroPilot® technology on Caterpillar 3406 since 1997 (MicroPilot® is a registered trademark of Clean Air Partners)

Slide courtesy of Clean Air Partners